IMPACT OF HAIL SUPPRESSION ON NEBRASKA CROP PRODUCTION: A SIMULATION STUDY

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Hay	Simulation
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Prices	
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SUMMARY

A linear programming analysis was used to simulate the effects of different rates of hail suppression on crop production in Nebraska. Production costs and crop patterns in ten major land resource areas (LRAs) in Nebraska were estimated for 10-percent, 25-percent, and 50-percent levels of hail suppression effectiveness, and compared to costs and production distribution patterns without hail suppression. A mathematical model (solved by a classical linear programming technique with a cost-minimization objective) was employed in making the estimates. The study, limited to Nebraska, focused on analyzing shifts in location of crop production that might occur from changes in the comparative advantage of ten different LRAs.

The simulation results indicated that if a successful program of hail suppression had been conducted in Nebraska with hail suppression effectiveness of 50 percent, total corn production would have been 2 percent higher, and wheat production would have been 3.7 percent higher. Total production costs would have increased less than one-half of a percent in the State. Assuming these estimated changes in crop production and costs had occurred, there would have been only small shifts in the pattern of crop production among areas of the State.

With hail suppression, production shifts of the same crop <u>between</u> LRAs were generally minor, ranging from zero to about 20,000 acres. A loss of more than 1 percent of the total cropland in an LRA occurred in only two cases, and none of the LRAs had changes amounting to as much as 2 percent, regardless of the hail suppression level.

More crops were involved in acreage shifts at the higher suppression levels, but the range of acreage shifts was about the same at all levels of hail suppression effectiveness. In most cases, the acreage of a crop lost by an LRA represented a much lower percentage of the total acreage of that crop in the LRA than it did in the area that gained acreage. Most of the shifts represented a deconcentration of acreage of the particular crop.

Likewise, hail suppression would not have caused substantial shifts of land use from one crop to another <u>within</u> an LRA. Most of the changes within LRAs were due to shifting crop production to a different quality of land, rather than to intercrop competition.

Changes in total factor demand, as measured in dollar costs of production, varied considerably in magnitude from one LRA to another and from one hail suppression level to another. These changes resulted from acreage shifts due to hail suppression.

Total crop production would have increased at all hail suppression levels, except for two minor crops: irrigated alfalfa and irrigated sorghum for grain.

Simulating annual changes in production expense by area (average cost per acre) permitted some tentative indications of the changes in factor demand. Constant prices received by farmers were used, reflecting an assumption that the aggregate demand and price situation is not affected by hail suppression technology. However, if hail suppression technology were widely used it could influence production of some crops enough to change price.

THE IMPACT OF HAIL SUPPRESSION ON CROPPING PATTERNS IN A MULTI-AREA PRODUCING REGION

Larry M. Boone 1/

INTRODUCTION

Technology intended to suppress hail is being applied both experimentally and commercially in the United States. While some evidence exists that the technology is effective in suppressing hail, it is not yet "proven" in the sense that either reliable predictions or satisfactory measurements of effect can be made. Continued funding of experiments and commercial projects indicates substantial interest in hail suppression. This interest warrants investigation of how the large scale introduction of effective hail suppression technology into our agriculture might affect crop production and those involved in farming, supplying factor inputs and financing.

New technologies generally affect crop production by changing yields and/or the costs of producing crops. Some innovations such as machinery improvements are of interest to nearly all farmers and are almost universally adopted. The impact of such technologies is in the aggregate quantity of crop produced, or the overall level of production costs in the industry, with little change in the competitive positions of farmers in different regions. Other forms of technology, such as hail suppression, are of greater interest to certain groups of farmers, (e.g., those in areas of high hail risk), and may change the competitive positions of producers adopting the practice relative to those who do not adopt. Aggregate production and cost levels may or may not be affected, depending upon the portion of the total crop produced in areas where the technology is beneficial.

The Economic Research Service, U.S. Department of Agriculture, in cooperation with the National Science Foundation is conducting research on various phases of hail suppression technology. This report deals with the economic impact of hail suppression on cropping patterns. It is one of a series of reports growing out of the larger study.

OBJECTIVE

The basic objective of this phase of the research was to estimate (or simulate) the annual effects on total crop production and costs if different rates of hail suppression had been practiced in given years. It does not attempt to predict what individual farmers would do and is limited only to the State of Nebraska.

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Specific objectives were to:

1. Analyze shifts in the location of crop production that might occur from changes in the comparative advantage of different regions of Nebraska.
2. Estimate the potential impact on total production costs of varying annual hail suppression rates.

The focus of the analysis was on changes in aggregate land allocation, and costs of production, rather than on maximization of profits from production.

Distribution of cropland among individual producing units and how the units might be adjusted due to the changes were not part of the analysis.

ASSUMPTIONS AND METHODS USED IN ANALYSIS

Even with high prices for agricultural commodities, it seems unlikely that hail suppression will have a major impact on overall industry production and costs. In earlier work, [2]* the author estimated crop losses due to hail compared to the total value of crops produced in the United States. Assuming that those estimates were reasonably valid, eliminating one-half the annual hail damage to the nation's crops would save crops worth around $200 million at 1968 commodity prices. Though it may appear substantial, such an increase is small compared to the impacts of other technological developments during recent decades. In addition, only the more optimistic persons involved in weather modification development research would currently predict a hail suppression technology capable of delivering a 50 percent reduction of crop damage in continued, large scale application.

The distribution of the impact of hail suppression among producing regions is difficult to assess. Hail risk differs markedly from one producing area to another suggesting that the impact of hail suppression on the competitive positions of producing areas within an agricultural region might be more significant than changes in aggregate production. The purpose of this phase of research was to develop some "first generation insights" into the shifts in cropping patterns which might occur among areas within an agricultural region from application of effective hail suppression technology.

In the economic assessment of an existing technology, certain physical effects of the technology can be observed. Impacts of these effects are then hypothesized and analyzed, subject to a set of economic assumptions intended to simulate the reality surrounding the intended use of the technology.

Assessment of the economic impact of a technology not yet developed, or at least not yet proven, is unusually sensitive. In the case of hail suppression, even the physical effects must be assumed. This serves to emphasize the importance of clarity with regard to the impacts which are hypothesized for analysis. Clarity, rather than sophistication, will be sought in the following consideration of impacts which should be analyzed.

A frequent criticism of technology assessment studies is that they overemphasize the estimation of "primary" or direct effects and ignore the

*Underscored numbers in brackets refer to references cited at the end of the text.

important "external" or secondary effects. Distinctions between the two are not clear in all cases. In any event, the direct effects must be estimated before secondary effects can be evaluated. Given the nature of the objectives of this phase of the research, it would be expected that the primary emphasis would be on direct effects, and there is no claim to have estimated all possible effects.

Analysis of the impact of a technology which is not yet developed may not be as unproductive as it first appears. Such analyses are based on assumed levels of performance of the technology and are admittedly only first approximations of results that might be expected. However, they provide some insight into economically feasible performance levels during the process of scientific development when such information should be of maximum value.

THE NATURE OF THE IMPACT OF HAIL SUPPRESSION

If hail suppression is proven effective, its basic effect on crop producers will occur in two parts, though farmers are so experienced in the adoption of new technology that they probably will recognize only one familiar effect. The two parts of this basic effect are illustrated in figures A and B, below. Figure A represents a schedule of the quantities of a crop which can be produced with different levels of productive factors, in other words, a production schedule or function. Figure A is generalized from the standard classroom production function in that the horizontal axis represents larger "bundles" of land, labor, and capital rather than the usual increasing amounts of one factor applied to fixed quantities of the others. This does no violence to the concept of the production function as long as the bundles are viewed as the "best" combination of factors for the production of that crop, given their availability, prices, and relative contributions to production.

Figure B represents the marginal cost schedules, that is, the cost of producing each additional unit of output represented by a movement up the production functions in figure A. The market price, represented by a horizontal line in figure B, establishes the upper limit of economical production at prevailing prices of productive factors and the product in question.

The situation before hail suppression may be determined from cost curve MC_1 in figure B and production function TP_1 in figure A. Market price, P, puts the most desirable production level at Q_1 (fig. B). To produce more means that some costs are not covered by the market price, and to produce less is to sacrifice profit on all units of product which can be produced at a cost less than the market price. Quantity Q_1, in figure A, can be produced with a bundle of productive factors F_1.

The first part of the basic effect of hail suppression is to reduce the physical destruction of crops by hail. The same bundle of productive factors, F_1, or any other bundle can now produce more physical output. This result is represented by shifting to a new, and higher, production function TP_2, and production of a larger quantity Q_3. At the same time, greater production from the same productive factors indicates a lower production cost per unit represented by shifting to a lower cost curve MC_2 (fig. B).

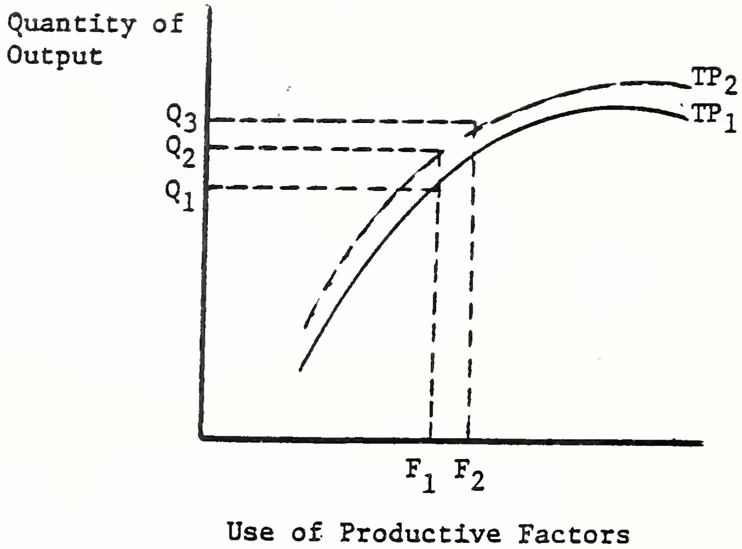

Figure A: Total product curve (TP) for a set of variable inputs or production factors combined according to the scale line.

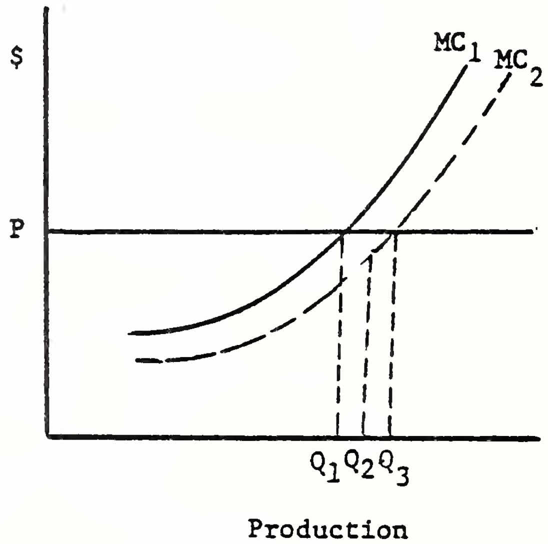

Figure B: Marginal cost curve (MC) and market price (P) showing optimum level of production (Q).

With the price unchanged, an assumption indicated in the previous section and discussed at more length below, all units of quantity Q_2 can be produced for less than market price (indicated by MC_2 being below the price line at quantity Q_2). At this point the second part of the basic impact of hail suppression enters. With production function TP_2 and cost schedule MC_2, the market price indicates an optimum production level of Q_3. This provides incentive for the producer to expand output, which requires a larger bundle of productive factors F_2.

Expanded production and increased demand for productive factors are two aspects of the impact of hail suppression which should be considered in an assessment of the technology. However, a one crop-one producer or one crop-one area impact, such as the above, cannot be expected to raise all the pertinent questions. The application of hail suppression over several areas and crops with different levels of effectiveness will create interesting questions with regard to both net and interaction effects. Two of the more important potential effects are: (a) production shifts of the same crop between two areas affected differently by hail suppression; and (b) production shifts between two crops affected differently by hail suppression within the same area.

The way in which hail suppression may cause a shift from one crop to another in the same area is illustrated in figure C. The lower curve represents the production possibilities for two major crop alternatives with no hail suppression. If all available resources were devoted to crop A, the quantity of crop A represented by Oa can be produced. If they were devoted to crop B, Ob can be produced. The curve represents the mixes of the two crops which can be produced. The mix actually produced is determined by the ratio of the prices of the two crops.

In figure C, the tangential line representing the ratio of crop A and B prices fixes the optimum production mix at quantities indicated by Q_1 for each crop. Hail suppression is assumed to benefit crop B more than crop A. Thus, the new production possibilities curve (the upper curve) shows a small increase on the crop A axis and a larger increase on the crop B axis. At the same price ratio (indicated by the same slope to the price ratio line) there will be a shift to crop B, indicated by quantities Q_2 for each crop. This may bring about either a reduction or an increase in specialization of production, depending upon the original degree of specialization and which crop receives the greater benefit of the technology.

Figure D illustrates the general mechanism through which competitive positions in the production of a crop may be shifted from one area to another where the areas receive unequal benefit from hail suppression. The cost curves and price level interact to determine the quantity of production in each area exactly as they did in figure B above. The greater benefit of hail suppression is assumed to accrue in area B, indicated by the greater shift in its marginal cost curve. In other words, area B gains competitive position with regard to this crop. The net result of hail suppression in these two areas, however, depends upon what happens to their competitive positions regarding other crops and other areas, and how the effects illustrated in figure C change the relationship among crops within each area.

The foregoing has identified the mechanisms through which impacts relevant to crop production patterns and competitive production positions

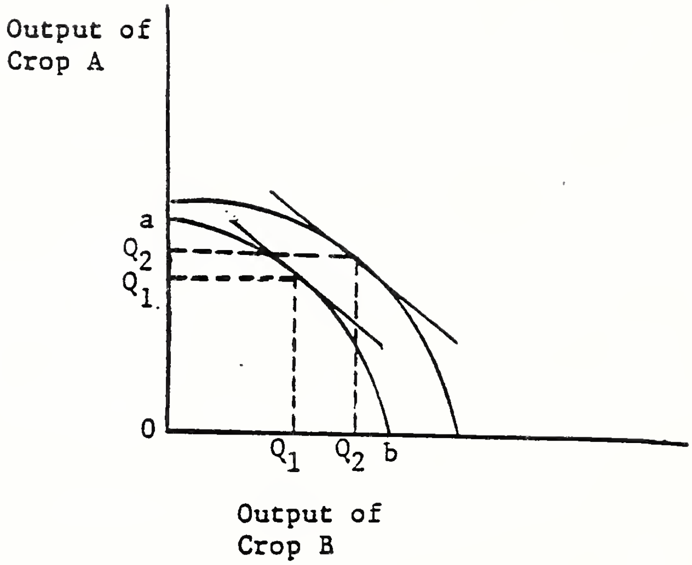

Figure C: Iso-cost cost curves with superimposed iso-revenue curves.

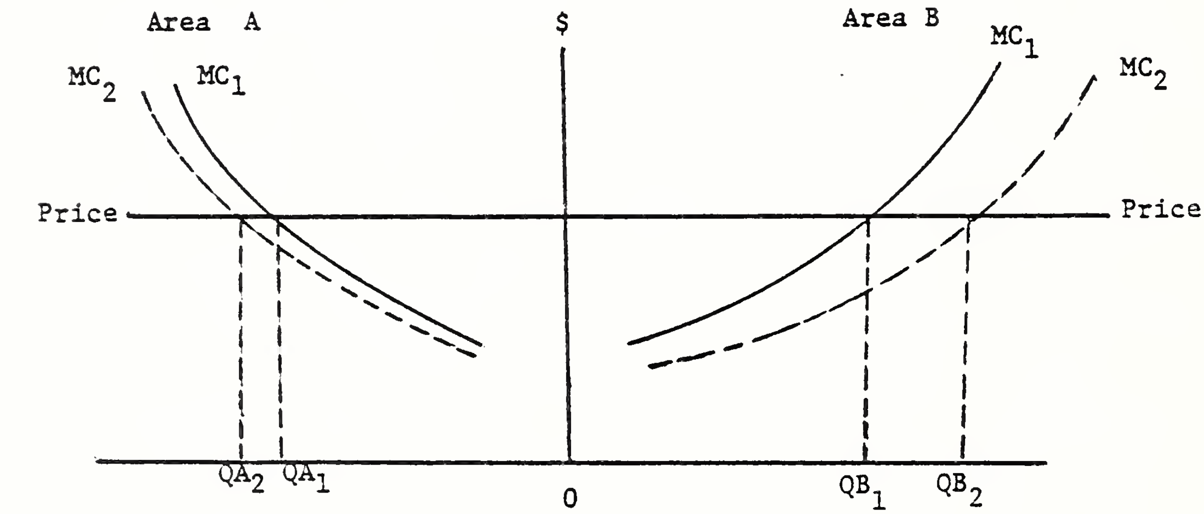

Figure D: Marginal cost curves and market price showing effect of cost changes on output in two areas.

might result from the application of effective hail suppresion technology. Data for the analysis which follows were based much too heavily on assumption to seek precision in estimated marginal cost and acreage changes. Rather, a general estimate of overall production change was sought, along with the relative importance of crop shifts between and within areas. A rough measure of changed production expense by area (average cost per acre) permits some tentative indications of the change in factor demand.

To prevent possible misinterpretation throughout this report, it should be made clear at this point that the use of constant prices (1971) in the above illustrations does not indicate an assumption of infinite final demand for agricultural products. Demand is assumed to be constant, or at least is not assumed to be affected by the existence and use of hail suppression technology. The assumption of constant prices was tentative, and was based upon supply considerations, including the following: (a) the analysis is to be a one region consideration. If the use of hail suppression technology improves the competitive position of one region relative to others any expansion of production in that region will tend to be offset by declines in production in the other regions; and (b) the crops sustaining the largest volume of losses due to hail are major crops grown in many parts of the country. The loss as a percent of total volume produced is not large, although the dollar value can be substantial for the producers affected. It was felt that the physical reduction in loss alone in one region would not increase national production enough to affect prices.

It is recognized that if hail suppression is proven effective, it will probably be in demand in many producing regions. If the technology were widely used, even with some production tradeoffs among regions, it could alter production of some crops enough to change prices.

ANALYTICAL REQUIREMENTS

Much technical data were needed for use in the model used in this study. These requirements are discussed below.

Region and Area Definition

An analysis of the type outlined above requires subarea data on costs of production, acreage, yields, and hail loss. The producing region chosen for analysis needed to be small enough to permit management of these data, and large enough to avoid too much homogeneity of factors. The State of Nebraska was chosen as a producing "region" with desirable attributes for such analysis: a transitional agriculture including a variety of crops, and wide variations in hail loss from area to area within the State, as indicated by insurance records from the Crop-Hail Insurance Actuarial Association of Chicago, Illinois.

A framework of subareas within the region was also needed, with enough identity in common data sources to minimize data interpolations and extrapolations. The county is the basic data unit for many types of information, but was judged unacceptable as an analytical unit for this analysis for two reasons. One was that Nebraska has 93 counties which would lead to numerous duplications of data formations. More importantly, much of that duplication would be uninformative, and possibly confusing, because of the homogeneity

of various groups of counties in different parts of the State. At the same time, it was desirable to retain the use of the "identifiability" of the county in data sources, which suggested the use of multicounty producing areas for which county data could be aggregated readily.

In the mid-1960's, the Soil Conservation Service of the U.S. Department of Agriculture defined a series of 156 major Land Resource Areas (LRAs) encompassing the entire continental United States (1). These LRAs are geographic areas of land characterized by overall similarities in patterns of soils, climate, water resources, land use, and type of farming. Ten of these LRAs extend into Nebraska's borders and include all the land in the State.

The original LRA boundaries were entirely physiographic. Within Nebraska and other Missouri River Basin States, however, those boundaries have been generalized slightly to conform to the nearest county line. This convention allows use of aggregated county data to obtain LRA totals without interpolating partial county estimates. Figure E indicates the boundaries of the ten LRAs in Nebraska, and their identifying numbers.

Another set of subarea delineations has been made by the Soil Conservation Service. A series of Soil Resource Groups (SRGs) have been defined, with each group sharing similarities in productive capability of soil, soil loss, cropping patterns, response to fertilizer and management. The activity of SRG definition was completely separate from the delineation of LRAs, but the SRGs were defined within the framework of LRAs. Table 1 shows some examples of the characteristics considered in defining SRGs. The SRGs provide subunits of productive capability within LRAs. The acres of land in each SRG in each county is known, as are the average yields of major crops produced on the soils of each SRG. A workable set of yield differentials was thus established for the various identifiable soil groups within an LRA, and within each county.

Analytical Model

A model was needed for the analysis which would simulate changes in crop acres, production costs, and yields across several subareas and for several crops. Simulated cropping patterns and cost levels were desired for situations representing the "with" and "without" hail suppression cases, and for different assumptions of hail suppression effectiveness.

The McDonnell Automation Company and the Economic Research Service have developed the Generalized Agricultural Production Analytical System (GAPAS) which includes the necessary capabilities. GAPAS is a system of programs built around a mathematical model solved by a classical linear programming technique and includes a matrix generator and report generation capabilities. While the system was developed to analyze the effects of long-term water and land resource development programs, it was easily adapted for the purposes of this research.

Linear programming codes are used to solve many types of problems, and inputs for any given type of problem must be within a rigidly defined format. The matrix generator of GAPAS is essentially a program to reform a variety of input data to the required formats, and to prepare a matrix to be solved by a linear programming code.

The mathematical model, the set of equations prepared by the matrix generator, is solved by the linear programming code MPS/360 developed by IBM.

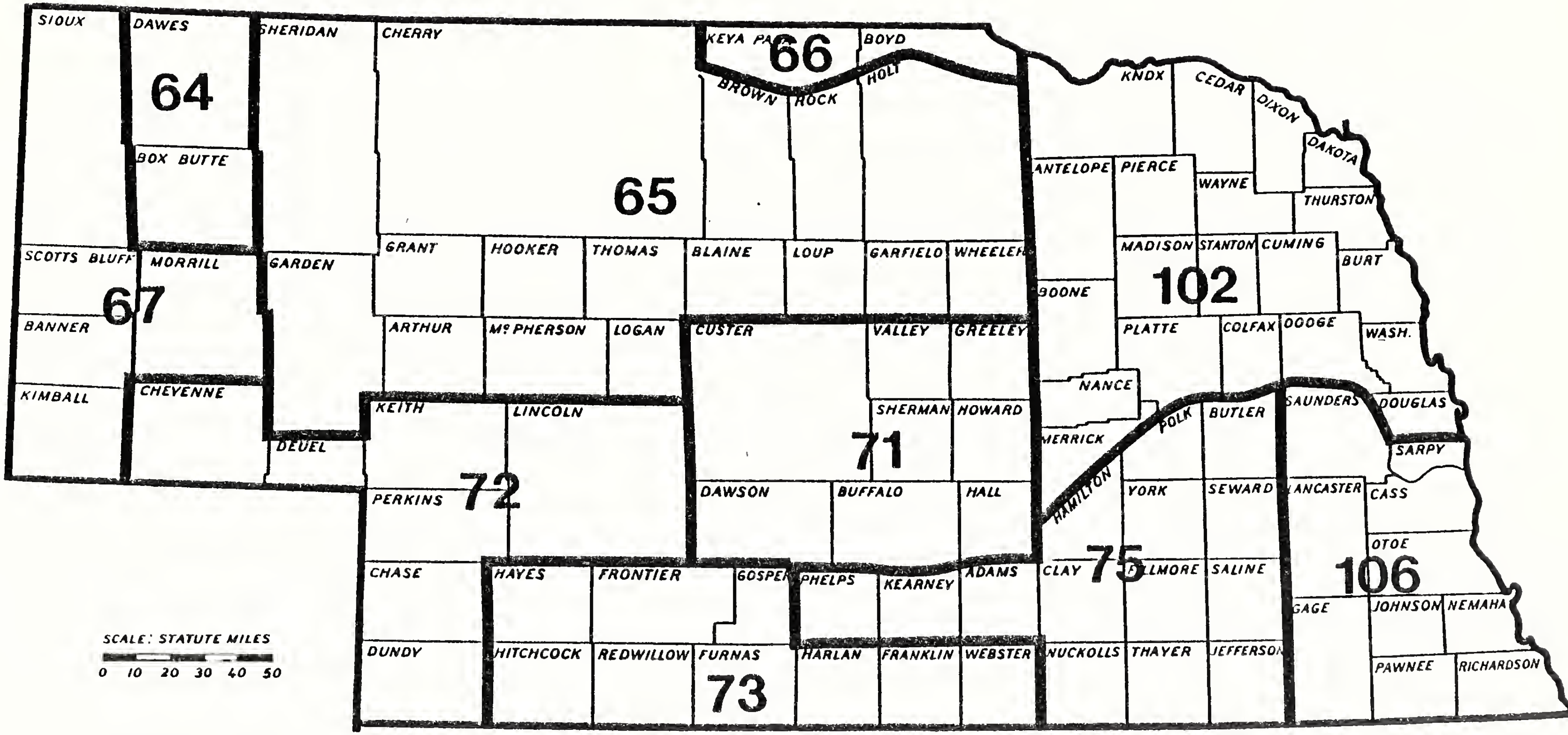

Figure E.--Land Resource Areas (LRAs), Nebraska.

Table 1.--Examples of soil characteristics considered in the definition of soil resource groups (SRGS) in Nebraska

SRG Code	Description	Major Soils		Slope	Texture class	Problems
		Class/Subclass	Names			
720	Deep, gentle slopes,	2E10 2E20 2S10 2E90	Moody, Hastings, Keith, Holdrege, Holder	3%	Fine-silty	Erosion
724	Deep, moderately to well drained, uplands	2W20 2W30 2W40 2W60	Colo, Carusd, Gibbon, Hobbs, Las Animas, Leshara, McCook, Wann	1%	Fine-silty and coarse-loamy	Wetness and occasional flooding
740	Deep, sloping, well drained, upland	4E10 4E20 4E80 4E90	Coly, Uly, Colby	5%+	Fine-silty	Erosion
543	Shallow, poorly drained, bottomland	4W4X	Platte	1%	Clay-sand	High water table, drought
510	Deep, level, well drained, silty, bottomland	1W 1X 1C 3X	Kemebec, Hobbs	1%	Fine-silty	Occasional flooding in some areas

The code will solve problems of up to 8,191 equations and an unlimited number of variables. The user's manual for MPS/360 is IBM Manual H20-0291-1.

The basic intent of the analysis was to estimate (or simulate) land use changes which might have occurred in a given year had hail suppression been practiced, rather than predict future effects. Both maximization and minimization objective functions could serve this purpose, with certain differences in required constraints. Since the focus of the analysis is on land allocation rather than on profit or production maximization, and since prices are fixed in a static time sense, the cost minimization approach was chosen.

Solutions and Constraint

As in any cost minimization linear program, the objective was to produce an indicated output level at minimum cost by the optimum allocation of resources available, subject to whatever constraints limit resource mobility and use. In this case, the indicated output levels were the actual 1971 production levels of the crops included. In the interest of consistent cost comparisons between "current" crop patterns and those estimated to result from hail suppression, it was necessary to "calculate" costs of current production levels with the current land use pattern, in accordance with the budget data in the model. Estimates of the minimum cost of producing current output levels without hail suppression if crop patterns were allowed to vary as they would with hail suppression was also required. Minimum levels of production and land use had to be specified to prevent the ultimate in cost minimization, i.e., zero production.

Data Format

The GAPAS system requires some unique ways of handling the data input. Interpretation of the results of the analysis will be easier if these unique characteristics are understood.

PRODUCTION COST MODE

In 1967 the Economic Research Service developed a series of variable production cost budgets for crops grown in Nebraska LRAs. The budget data were obtained from University of Nebraska budget studies, farm records, and consultation with Cooperative Extension Service personnel. The budget format, illustrated in figure F, was developed to match the data input mode of the GAPAS system.

The budget data were updated to the 1971/72 crop year for this analysis by consultation with staff members of the University of Nebraska's Department of Agronomy and with Cooperative Extension Service personnel. The data format, already suited to the GAPAS system, was retained.

Input production costs for each crop and LRA are developed in three parts, as indicated by the example in figure F. Part A includes costs of field operations and purchased inputs except for fertilizer. These are basic variable production costs which are considered constant for each crop across all SRGs in the LRA. Labor and nonlabor components are separately maintained. Part A costs are assumed to be adequate to cover harvesting of a base LRA yield.

In addition to the basic variable LRA costs, there are additional costs incurred in cultivating, irrigating, and maintaining heavy soils and steep

LRA 72 irrig. ______ nonirrig. X

FIXED LRA COSTS (A)

Operation	Size of equip.	Size of tract.	No. of op.	Hrs. per acre	Rate/hour Tract.	Rate/hour Equip.	Rate/hour Labor	Cost/acre Labor	Cost/acre Non-labor
							2.50		
Plow	5-14	5P	1	.40	2.10	1.94			1.62
Disk-Tandem	16'T	5P	1	.18	2.10	1.70			.68
Harrow, spike	25'	5P	1	.10	2.10	.47			.26
Plant	4R	4P	1	.20	1.85	2.00			.77
Rotary hoe	14'	4P	1	.15	1.85	1.37			.48
Cultivation	4R	4P	2	.45	1.85	.92			1.25
Pick	2R	4P	1	.50	1.85	3.00			2.42
Haul & Store		4P		.50	1.85	.60			1.23
Labor total				2.48				6.20	
Total - operational costs								6.20	8.71

Materials (No fertilizer)	Unit	$/Unit	Units/acre	Cost	Labor	Non-labor
Seed	lb.	.47	12	5.64		
Herbicide				1.96		
Insecticide				3.20		
Total - material cost						10.80
TOTAL FIXED LRA COSTS (A)					6.20	19.51

SRG DIFFERENTIAL COSTS (B)	Slope/texture L	Slope/texture NL	Maintenance L	Maintenance NL	Other L	Other NL	Total (B) L	Total (B) NL
SRG:								
Category B	.11	.16	.50	.75			.61	.91
Category C	.28	.41	.60	.90			.88	1.31
Category D	.46	.66	.70	1.05			1.12	1.71

VARIABLE HARVESTING COST (D)

Base yield	Cost/unit above: L	Cost/unit above: NL
50 bu.	.04	.06

Notes: Herbicide 56% acres treated @ $3.50/treated acre.
Corn rootworm 60% of acres @ $4.00 = $2.40
Corn borer 20% of acres @ $4.00 = .80
$3.20

Figure F.--Production cost budget, LRA-72 example: Crop--corn, grain.

slopes. The Soil Conservation Service has divided Nebraska SRGs into four groups on the basis of soil texture and degree of slope. One group requires no texture-slope cost differential, while the other three include increasingly heavy or steep soils requiring increasing cost differentials. Part B of the budget form consists of cost increasing factors for those SRGs requiring them.

Table 2 lists SRGs in each slope-texture group. Increased tillage and maintenance costs may result from a variety of causes. Thus we find SRG 740, characterized by slopes of 5 percent or more with silty soils, in the "C" category along with SRG 746, which has 0-2 percent slopes, but soils tending to clay. Most of the "B" soils are fairly level, but are slightly heavy or in some cases, such as SRG's 522 or 525, they have a slight drainage or flooding problem. Most of the "D" soils are steeply sloping and may be rocky. An exception is SRG 745, which has slopes of only around 2 percent but includes shallow soils over bedrock or gravel.

Table 2.—Categories of soil resource groups within Nebraska

Category				
A	B		C	D
536	510	722	734	745
710	521	723	739	760
720	522	724	740	764
721	523	725	743	765
726	525	730	746	771
731	531	732	770	772
733	534	735	773	
736	535	737	761	
738	541	741		
	543	742		
763	544	744		
	550	750		
	561	762		
	562			
	570	780		
	580	791		

For some crops, such as sugar beets and hay crops, harvesting costs are probably more accurately reflected if considered entirely a function of yield. Where this was considered true, harvesting costs were eliminated from part A, and the base yield in part D set at zero. The system calculates costs based on total yield. For other crops, part A costs were considered adequate to cover the harvesting part of the normal yield. In these cases, the system calculates the cost of harvesting yields higher than the base, and adds that amount to the total cost.

Fertilizer costs were excluded from the basic budgeting process because they are internally calculated in the GAPAS system. To allow for variable

fertilizer input and cost, the GAPAS system calls for specification of fertilizer consumption in pounds of N, P, and K per bushel or ton of yield. Fertilizer cost is calculated by multiplying yield by the quantity of nutrient per yield unit and by the price of the nutrient, plus a standard cost of application. This implies a linear relationship between fertilizer cost and yield. In figure G, this implied relationship is represented by line A.

The true nature of the relationship between fertilizer cost and yield is probably better represented by curve B. Starting at zero cost and a positive yield (some production can be obtained without fertilizer), the cost of fertilizer increases at a greater rate than the increase in yield. It was not feasible to measure the precise relationships for all crops in all LRAs. The linear approximation of the relationship was thought to be more accurate than another alternative represented by line C, the assumption of a single level fixed fertilizer rate for each crop and LRA.

To summarize, the total cost of production of a given crop in a given LRA and SRG is determined in stages. First, the basic cost of that crop in that LRA is determined from the budgets. Depending on the SRG, a differential cost may be added to cover slope, texture, and maintenance costs. If the yield is above the base yield, a variable harvest cost is added. Finally, the fertilizer consumed by that crop in that LRA is determined, and the costs of nutrients and their application are added to the total.

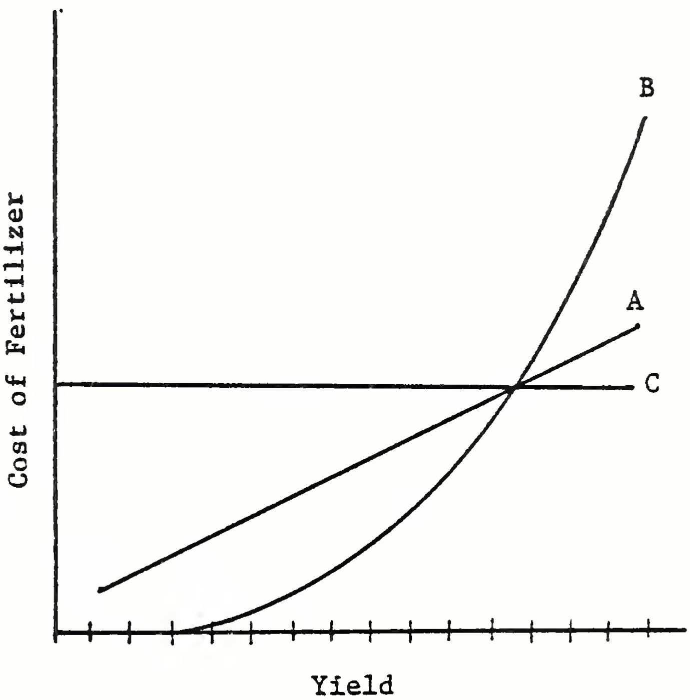

Figure G: Relationship of the cost of fertilizer and crop yield.

SOIL RESOURCE GROUP COMBINATIONS

As indicated above, the production cost budgets include differential cost factors for slope and texture. SRGs are grouped into four categories for that purpose. To reduce the number of soil categories in the analysis, SRGs in each differential cost category were further grouped on the basis of similar productivity indices. The result was a reduction in the number of SRGs with relatively homogeneous cost and productivity characteristics in each LRA. Rather than 30 or more, this analysis treated from 9 to 12 SRGs in each LRA. Individual SRGs are not identified in the results discussed later in this report, but their cost and productivity influences are included in weighted averages for each LRA. Appendix Table 1 shows how the SRGs were grouped by productivity indices within cost categories and LRAs.

HAIL SUPPRESSION FACTORS

Estimates of the costs of hail suppression and its effect on crop yields were needed to set up the analysis of crop pattern changes resulting from it.

Suppression Costs

General estimates of suppression costs vary from 3½ cents to about 6½ cents per acre covered. These estimates vary especially with the kind and quality of equipment used and the training and experience of the personnel. Unfortunately, the inability to measure the effectiveness of hail suppression in terms of crop damage also makes it impossible to determine if the higher cost operation is more effective. The relative range in cost per acre can be fairly large, although cost per acre is not very high. For example, one western Nebraska LRA includes 3,608,000 acres of total area and 1,107,000 acres of cropland. Total suppression costs for this LRA at 3½, 5, and 6½ cents per acre covered would be $126,000, $180,000, and $235,000, respectively. In costs per crop acre, these values represent $.11, $.16, and $.21, respectively. In comparison with other production costs, differences among the above figures seem rather insignificant, so the suppression costs used in the analysis were based on a cost of 5 cents per acre of total area in the LRA. Table 3 shows how this cost translates into costs per crop acre for the ten LRAs in Nebraska. 2/ [3]

2/ Unfortunately, until a proven hail suppression technology has been developed, the relevant cost is difficult to specify. Based on experience gained in the National Hail Research Experiment in Colorado over the past 4 years, scientists and economists familiar with suppression techniques currently used now feel that more sophisticated equipment and techniques may be necessary. Such equipment and techniques could increase costs to as much as 40 cents or more per acre of protected area.

Yield Effects

The difficulty and expense of measuring hail suppression results in terms of a definite ground-level effect means that there are no solid data to express the yield increases expected to result from use of the technology. In order to estimate such yield increases, it was necessary to use assumed levels of effectiveness of hail suppression. There are two points of considerable importance regarding those assumptions.

Table 3. Hail suppression cost per crop acre in Nebraska LRAs, assuming a cost of $.05 per acre of total land area

LRA	Total acres	Cost for total area	Crop acres	Cost per crop acre
	Acres	Dollars	Acres	Dollars
64	1,447,548	$ 72,377	456,840	$.16
65	13,303,186	665,159	1,239,209	.54
66	825,908	41,295	219,723	.19
67	3,608,442	180,422	1,107,374	.16
71	4,544,702	227,235	1,961,259	.12
72	4,950,394	247,520	2,262,237	.11
73	3,721,009	186,050	1,859,508	.10
75	4,751,417	237,571	3,690,540	.06
102	6,616,235	330,812	4,531,828	.07
106	3,407,216	170,361	2,492,361	.07

First, weather modification scientists are reluctant to speculate about the effectiveness of hail suppression technology, either in its current state, or in the more advanced forms they are trying to develop. Therefore, although the assumptions used in this analysis are felt to be in the general range of expectation of many of those scientists, they are attributable only to the author.

Second, the frame of reference used in this report for the level of effectiveness of hail suppression is a reduction in the loss of crops. Such a ground-based measure is somewhat removed from the cloud-based phenomena being studied by meteorologists and cloud physicists in relation to hail suppression. When their references to suppression effectiveness appear, they will relate to updrafts, hailstone concentrations, hailstone sizes, velocity of impact, etc.

There are no precise, predictable relationships which can be drawn at this time between the two frames of reference. Work now underway at the National Center for Atmospheric Research in Boulder, Colorado, will attempt to estimate such relationships.

Three levels of hail suppression effectiveness were assumed in order to test the impact on production costs and crop patterns of a range of possible suppression results. Effectiveness levels of 10 percent, 25 percent, and 50 percent were applied to existing loss rates to estimate yield increases resulting from suppression. The procedure for estimating the yield increase was as follows. If the current rate of loss due to hail of a given crop in a given LRA is 8 percent, the increase in yield is equal to the reduced loss. Thus, at 10 percent effectiveness (10 percent loss reduction) the yield increase is .8 percent of current yield; at 25 percent effectiveness it is 2.0 percent and at 50 percent effectiveness, 4.0 percent. Yield increases were estimated for each crop in each LRA for use in those parts of the analysis treating the "with hail suppression" situation. Minimum cost linear programming solutions were obtained under assumptions of: (1) no hail suppression (2) 10 percent effective, (3) 25 percent effective, and (4) 50 percent effective hail suppression to determine what changes in costs and distribution of crop production would occur.

There are a number of ways in which a technology such as hail suppression can affect a region. The several solutions of the model are viewed from various viewpoints to highlight some of the more interesting potential impacts of hail suppression on crop production and costs for a region.

All solutions discussed, unless otherwise indicated, are minimum cost solutions for the State. Crop patterns vary, sometimes substantially, from the "current" crop distribution among LRAs. ("Current" refers to the most recent reliable data at the time of the study, on crop distribution by LRA and SRG, or about 1971.) This variation from the current crop pattern was a necessity in testing the impact of hail suppression on the location of production. The "without hail suppression" case was also a minimum cost solution to avoid attributing to hail suppression large location shifts due to the minimum cost combination of production locations.

ESTIMATED IMPACTS OF HAIL SUPPRESSION

Effects of hail suppression on crop acres and production and production costs were estimated for land resource areas. The results of these analysis are reported below.

Total Production and Cost of Production

As a general overview, table 4 indicates State production levels under each of the hail suppresion level assumptions indicated above, and the total cost of producing each crop mix. Changes in production include the effect of both physical reductions in hail loss and changes in acreage. Cost changes include both the cost of hail suppression and any changes in the use of productive factors. These components will be viewed in greater detail below.

Distribution of Crops Within and Between LRA's

Tables 5, 6, and 7 indicate the estimated acreage changes resulting from suppression levels of 10 percent, 25 percent and 50 percent devoted to each crop in each LRA. Reading down the columns gives an idea of the shifts among crops within an LRA. Across each line, the shifts of a given crop from one

Table 4.--Crop production and total production costs: Without hail suppression and at three levels of hail suppression effectiveness, Nebraska

Crop	Units	Without hail suppression	With hail suppression effectiveness 10%	25%	50%
Production					
Wheat, dryland	Bu.	94,291,268	94,977,866	96,076,948	97,777,188
Wheat, irrigated	Bu.	77,032	77,734	78,852	80,612
Corn for grain, dryland	Bu.	144,392,994	144,808,593	145,382,848	146,678,017
Corn for grain, irrigated	Bu.	234,736,606	235,838,106	237,448,452	240,178,083
Sorghum for grain, dryland	Bu.	96,399,551	96,579,541	96,759,691	97,003,136
Sorghum for grain, irrigated	Bu.	15,077,249	15,104,059	15,143,709	15,446,664
Soybeans, dryland	Bu.	19,387,066	19,467,585	19,482,314	19,822,306
Soybeans, irrigated	Bu.	1,783,134	1,798,215	1,816,586	1,858,194
Sugar beets, irrigated	Tons	1,403,400	1,408,000	1,414,900	1,433,600
Other small grains, dryland	Bu.	22,469,300	22,611,800	22,803,900	23,161,700
Corn for silage, dryland	Tons	2,917,820	2,917,945	2,919,090	2,926,761
Corn for silage, irrigated	Tons	2,344,679	2,346,354	2,349,310	2,361,839
Sorghum for silage, dryland	Tons	1,199,875	1,199,972	1,200,132	1,208,648
Sorghum for silage, irrigated	Tons	193,025	193,328	193,667	190,252
Alfalfa, dryland	Tons	3,301,338	3,013,338	3,008,021	3,017,785
Alfalfa, irrigated	Tons	875,162	875,162	886,279	883,015
Other tame hay, dryland	Tons	1,065,065	1,065,065	1,065,065	1,066,365
Other tame hay, irrigated	Tons	98,635	98,635	98,635	98,635
TOTAL PRODUCTION COSTS	Dollars	547,134,000	547,618,000	548,351,000	549,695,000

Table 5.--Acreage changes at the 10 percent suppression level, by crop and LRA, Nebraska

Crop	LRA 64	65	66	67	71	72	73	75	102	106
NI Wheat	- 31	-	-	-	-	-	-	-	-	- 122
NI Other small grain	-	-	-	-	-	-	-	-	- 100	-
NI Corn for grain	-	-	-	-	-	-	-	-	-	-
NI Corn for silage	-	-	-	-	-	-	-	-	-	-
NI Sorghum for grain	-	-	-	-	-	-	-	-	-	+ 113
NI Sorghum for silage	-	-	-	-	-	-	-	-	-	-
NI Alfalfa	-	-	-	-	-	-	-	-	-	-
NI Other tame hay	+ 63	- 67	-	-	-	-	-	-	-	-
NI Soybeans	-	-	-	-	-	-	-	-	-	- 17
NI Fallow	- 32	-	-	-	-	-	-	-	-	-
NI Net change	-	- 67	-	-	-	-	-	-	- 100	- 26
IR Wheat	-	-	-	-	-	-	-	-	-	-
IR Corn for grain	-	-	-	-	-	+18,630	-	-19,322	-	-
IR Corn for silage	-	-	-	-	-	-	-	+ 46	-	-
IR Sorghum for grain	-	-	-	-	-	-	-	-	-	-
IR Sorghum for silage	-	-	-	-	+ 14	-	-	-	-	-
IR Alfalfa	-	-	-	-	-	-	-	-	-	-
IR Other tame hay	-	-	-	-	-	-	-	-	-	-
IR Soybeans	-	-	-	-	-	-	-	-	-	-
IR Sugar beets	-	-	-	+ 26	-	-	-	-	-	-
IR Net change	-	-	-	+ 26	+ 14	+18,630	-	-19,276	-	-
TOTAL NET CHANGE	-	- 67	-	+ 26	+ 14	+18,630	-	-19,276	- 100	- 26

NI = nonirrigated
IR = irrigated

Table 6.--Acreage changes at the 25 percent suppression level, by crop and LRA, Nebraska

Crop	LRA									
	64	65	66	67	71	72	73	75	102	106
NI Wheat	-	- 207	-	-	-	-	-	-	-	- 122
NI Other small grain	-	-	-	-	-	-	+13,820	-	-12,774	-
NI Corn for grain	-	-	-	-	-	-	-	-	-	-
NI Corn for silage	-	-	-	-	-	-	-	-	-	-
NI Sorghum for grain	-	-	-	-	-	-	+ 924	-	-	- 606
NI Sorghum for silage	-	-	-	-	-	-	-	-	-	-
NI Alfalfa	-	-	-	-	-	- 2,532	-	-	-	-
NI Other tame hay	-	-	-	-	-	-	-	-	-	-
NI Soybeans	-	-	-	-	-	-	-	-	-	- 7
NI Fallow	-	- 207	-	-	-	-	-	-	-	-
NI Net change	-	- 414	-	-	-	- 2,532	+14,744	-	-12,774	- 735
IR Wheat	-	-	-	-	-	-	-	-	-	-
IR Corn for grain	-	-	-	-	-	+18,630	-	-18,930	-	-
IR Corn for silage	- 4,335	-	-	-	-	-	-	- 1,682	+ 5,389	-
IR Sorghum for grain	-	-	-	-	-	-	-	-	-	-
IR Sorghum for silage	-	+ 80	-	-	- 56	-	-	-	-	-
IR Alfalfa	-	-	-	-	-	+ 1,394	-	-	-	-
IR Other tame hay	-	-	-	-	-	-	-	-	-	-
IR Soybeans	-	-	-	-	-	-	-	-	-	-
IR Sugar beets	-	-	-	+ 65	-	-	-	-	-	-
IR Net change	- 4,335	+ 80	-	+ 65	- 56	+20,024	-	-20,612	+ 5,389	-
TOTAL NET CHANGE	- 4,335	- 334	-	+ 65	- 56	+17,492	+14,744	-20,612	- 7,385	- 735

NI = nonirrigated
IR = irrigated

Table 7.--Acreage changes at the 50 percent suppression level, by crop and LRA, Nebraska

Crop	LRA 64	65	66	67	71	72	73	75	102	106
NI Wheat	-	- 370	-	-	-	-	-	-	-	- 122
NI Other small grain	-	-	-	-	-	+ 3,910	+13,820	-	-16,797	-
NI Corn for grain	-	-	-	-	-	-	-	-	-	-
NI Corn for silage	-	-	-	-	-	-	-	-	-	- 882
NI Sorghum for grain	-	-	-	-	-	-	+ 924	-	-	- 3,874
NI Sorghum for silage	-	+ 456	-	-	-	-	-	-	-	-
NI Alfalfa	-	-	-	-	-	-	-	-	-	-
NI Other tame hay	-	- 238	-	-	-	-	-	-	-	-
NI Soybeans	-	-	-	-	-	-	-	-	-	- 61
NI Fallow	-	- 370	-	-	-	-	-	-	-	-
NI Net change	-	- 522	-	-	-	+ 3,910	+14,744	-	-16,797	- 4,939
IR Wheat	-	-	-	-	-	-	-	-	-	-
IR Corn for grain	-	-	-	-	-	+20,268	-	-20,409	-	-
IR Corn for silage	- 5,017	-	-	-	-	-	-	+ 4,961	-	-
IR Sorghum for grain	-	-	-	-	-	-	+ 686	-	-	+ 1,672
IR Sorghum for silage	-	+ 194	-	-	- 197	- 196	-	-	-	-
IR Alfalfa	-	-	-	-	-	+ 173	-	-	-	-
IR Other tame hay	-	-	-	-	-	-	-	-	-	-
IR Soybeans	-	-	-	-	-	-	-	-	-	-
IR Sugar beets	-	+ 56	-	+ 58	-	-	-	-	-	-
IR Net change	- 5,017	+ 250	-	+ 58	- 197	+20,245	+ 686	-15,448	-	+ 1,672
TOTAL NET CHANGE	- 5,017	- 272	-	+ 58	- 197	+24,155	+15,430	-15,448	-16,797	- 3,267

NI = nonirrigated
IR = irrigated

LRA to another are indicated. The net change lines summarize total shifts among LRAs. Table 8 provides a quick and partial check on the logic or reason for a shift in cropped acreage by presenting the loss-cost values (approximate loss rates) for each crop-LRA combination for which a loss history is available.

At the 10 percent suppression level, for example, only one shift of major significance occurred between LRAs. Substantial acreage of irrigated corn for grain shifted from LRA-75 to LRA-72. Table 8 shows that LRA-72 has a loss-cost (approximate loss rate) more than twice that of LRA-75, indicating a larger potential benefit from hail suppression. In this case, that difference in benefit was apparently sufficient to improve the comparative cost position of LRA-72 relative to LRA-75.

It must be kept in mind that table 8 includes only part of the logic for a shift. As an illustration, it may be noted that LRA-72 has a soybean loss-cost nearly 8 times that of LRA-73, but no shifts in soybean acreage are indicated between these two LRAs at any suppression level. A differential loss-cost rate itself does not indicate a change in cost-advantage sufficient to cause acreage to shift.

Shifts from one crop to another within LRAs were minor at the 10 percent level. Table 8 is a less reliable indicator of logic in shifts within LRAs than production lost per unit. For example, in LRA-106 there is an apparent shift from dryland wheat to dryland grain sorghum (table 5), in spite of a lower loss-cost (lower potential suppression benefit) in grain sorghum. That change is probably best explained by the fact that LRA-106 had the lowest production cost per unit of grain sorghum of all LRAs both with and without hail suppression as shown in appendix table 2. This change represents a shift of some grain sorghum to lower quality land, requiring a few more acres to maintain about the same share of State production. (The shares of State production by LRAs are shown in appendix table 3.) 3/

With 25 percent suppression, the major shifts between LRAs were in dryland small grain other than wheat, irrigated corn for grain, and irrigated corn for silage. All those shifts were compatible with the loss-cost differentials of table 8, except the loss of irrigated corn for silage acreage in LRA-64 where insured loss history was not available. Most of the changes within LRAs were due to shifting crop production to a different quality of land, rather than intercrop competition.

The same comments apply to changes at the 50 percent suppression level. There are more shifts involving more acres, but all the major shifts between LRAs are consistent with the potential benefits indicated in table 8. The shift of dryland small grains from LRA-102 to LRAs-72 and 73 illustrates one small aspect of the internal working of the GAPAS system. Both LRAs-72 and 73 have higher loss-cost rates than LRA-102, and their gains in acreage are consistent in that sense. It may be noted, however, that LRA-67 has an identical loss-cost rate to that of LRA-72. Appendix table 2 further indicates that production costs per bushel are 2 cents lower in LRA-67 than in LRA-72. Production was allocated to LRA-72 rather than LRA-67 because the cost per acre is lower in 72. The system's logic is keyed to cost per acre, with the objective of finding the least cost land allocation to

3/ Because of the large bulk, cropping patterns by SRG are not included in this report.

Table 8.--Loss-cost rates (approximate loss rates) without hail suppression, by crop and LRA, Nebraska

Crop 1/	LRA									
	64	65	66	67	71	72	73	75	102	106
Wheat	9.98	8.64	5.40	12.41	5.93	9.87	6.93	4.56	3.74	2.63
Other small grain	16.91	6.91	4.77	11.93	5.98	11.93	12.14	3.88	3.76	2.95
Corn for grain	6.99	4.80	5.02	6.72	5.12	7.98	5.72	3.47	3.14	2.15
Corn for silage	-	-	-	-	-	-	4.84	.58	1.14	.65
Sorghum for grain	-	1.42	1.79	-	2.54	6.72	3.21	1.45	1.94	1.00
Sorghum for silage	-	9.50	-	-	.10	.10	.90	.95	.69	1.44
Alfalfa	-	6.05	.35	-	-	5.93	-	.49	1.30	1.13
Other tame hay	-	-	6.00	-	-	-	-	2.70	.86	-
Soybeans	20.80	18.89	4.21	9.20	11.34	23.74	3.02	5.07	4.62	3.32
Sugar beets	21.70	8.44	-	.73	11.36	-	20.42	6.30	.85	-

1/ Rates are the same for irrigated and nonirrigated.

produce a given output level. Theoretically, the ultimate outcome would be the same if the logic were keyed to cost per unit, but a few interesting anomalies occur.

Changes in acreage balance among crops within LRAs were generally minor except for the gains and losses related to shifts between LRAs. The percentage gains and losses for the major acreage shifts already pointed out will help provide perspective on the importance of those changes. The major acreage gains and losses, and the percentage change they represent from each LRAs acreage without suppression are as follows:

Crop	Gains	Losses
	10 Percent Suppression	
IR Corn for grain	LRA-72 18,630 acres (16.5 percent)	LRA-75 19,322 acres (2.1 percent)
	25 Percent Suppression	
NI Other small grain	LRA-73 13,820 acres (143.9 percent)	LRA-102 12,744 acres (4.0 percent)
IR Corn for grain	LRA-72 18,630 acres (16.5 percent)	LRA-75 18,930 acres (2.0 percent)
IR Corn for silage	LRA-102 5,389 acres (34.8 percent)	LRA-64 4,335 acres (53.7 percent)
		LRA-75 1,682 acres (6.5 percent)
	50 Percent Suppression	
NI Other small grain	LRA-72 3,910 acres (10.4 percent)	LRA-102 16,797 acres (5.3 percent)
	LRA-73 13,820 acres (143.9 percent)	
NI Sorghum for grain	LRA-73 924 acres (0.4 percent)	LRA-106 3,874 acres (0.8 percent)
IR Corn for grain	LRA-72 20,268 acres (17.9 percent)	LRA-75 20,409 acres (2.2 percent)
IR Corn for silage	LRA-75 4,961 acres (19.1 percent)	LRA-64 5,017 acres (62.2 percent)

The primary concern with the impacts of hail suppression is on the negative or loss side. To the extent that the acreage losses of specific crops might be concentrated within a particular LRA, it is obvious that the incomes of some groups of producers might be affected more than others. The actual income effect on those producers depends upon the availability of substitute crops and their ability to produce those crops at a profit.

A more comprehensive summary of the gains and losses of each LRA across all crops will provide a better perspective on the total impact of hail suppression. The net gain or loss of crop acreage and the percent of total cropland in the LRA represented by the change are summarized below:

Net change

LRA	10 percent suppression: Acres of crops shifted	10 percent suppression: Percent of total cropland	25 percent suppression: Acres of crops shifted	25 percent suppression: Percent of total cropland	50 percent suppression: Acres of crops shifted	50 percent suppression: Percent of total cropland
64	0	0	-4,335	.95	-5,017	1.10
65	-67	.01	-334	.03	-272	.02
66	0	0	0	0	0	0
67	+26	.00*	+65	.01	+58	.01
71	+14	.00*	-56	.00*	-197	.01
72	+18,630	.82	+17,492	.77	+24,155	1.07
73	0	0	+14,744	.79	+15,430	.83
75	-19,276	.52	-20,612	.56	-15,448	.42
102	-100	.00*	-7,385	.16	-16,797	.37
106	-26	.00*	-735	.03	-3,267	.13

*Positive but less than one one-hundreth of one percent.

Conclusions

In only two cases did any LRA gain or lose more than 1 percent of its total cropland, and none changed as much as 2 percent. Hail suppression apparently would have caused neither massive shifts in the location of production in the State nor substantial shifts of land use from one crop to another within an LRA.

TOTAL PRODUCTION AND TOTAL FACTOR DEMAND

Total State production of most crops increased with hail suppression effective at all three levels (table 4). The distribution of the increased production and the implications of that increase for the demand for productive factors may be more significant to producing areas than the acreage changes already discussed.

A reduction in production costs is generally considered a force for good, at least by farmers and those who work with them. One can hardly argue with that position in terms of cost per unit of product. When the discussion treats the total volume of factor demand, however, a reduction in total production costs (factor demand) may have a negative social cost.

As pointed out earlier, costs per unit generally declined or remained unchanged with hail suppression. The discussion at this point is concerned with the impact on rural area social and economic conditions brought about by changes in agricultural land use, total production levels, and the total demand for productive factors supplied by nonfarmer elements of rural communities.

The level of production of each crop in each LRA with each level of hail suppression effectiveness is shown in appendix table 4. Total factor demand (cost of production) related to those levels of production, including the cost of hail suppression are listed in appendix table 5.

At the 10 percent level, total factor demand increased in all LRAs except LRA-75, where it declined slightly. Even in that LRA, production of all crops increased or remained level, with the exception of irrigated corn for grain. Since corn is a very important crop in LRA-75, however, that decline was sufficient to reduce factor demand.

With 25 percent suppression, LRA-64 joined LRA-75 in the reduced factor demand column while all others increased. The reduction in LRA-64 was due to the loss of over half its irrigated corn for silage. LRA-75 regained only a part of the irrigated corn for grain lost at the 10 percent level, and in addition lost production of irrigated corn for silage.

At the 50 percent level, LRAs-64, 75, and 102 all show reductions in factor demand, while the rest show increases. LRA-64 lost more production of irrigated corn for silage; LRA-75 regained its production of irrigated corn for silage; and LRA-102, which actually lost some production of dryland small grains at the 25 percent level, lost enough of that crop at the 50 percent level to reduce total factor demand.

The magnitude of changes in total factor demand varied considerably from one LRA and suppression level to another. Changes by LRA and suppression level are summarized in table 9. The number in parentheses accompanying each dollar amount is the percentage of the total factor demand without hail suppression represented by the change.

Conclusions

Changes of less than 1 percent in the total demand for productive factors in most LRAs would not be likely to cause extremes of either prosperity or hardship. However, losses of 3-4 percent (as in LRA-64) or gains of 3-5 percent (as in LRA-72) could be significant—especially if the crop acreage were large and involved crops with a high per acre cost of production. The multiplier effect could be expected to amplify either increases or decreases of total factor demand in rural communities. However, the data used in this study were not precise enough to evaluate the influence of the multiplier.

Table 9.--Changes in the value of total factor demand, by LRA, for each suppression level

LRA	10 percent-level		25 percent-level		50 percent-level	
	$1,000	Percent	$1,000	Percent	$1,000	Percent
64	36	1/(.46)	-313	(4.02)	-283	(3.63)
65	17	(.07)	64	(.27)	195	(.83)
66	2	(.15)	4	(.10)	20	(.49)
67	36	(.14)	92	(.35)	180	(.69)
71	54	(.09)	120	(.19)	237	(.38)
72	1,434	3.86	1,600	(4.31)	2,016	(5.43)
73	66	.17	535	(1.39)	714	(1.85)
75	-1,248	.96	-1,287	(.99)	-447	(.35)
102	60	.04	384	(.26)	-112	(.08)
106	27	.04	18	(.03)	40	(.06)
State	484	.09	1,217	(.22)	2,561	(.47)

1/ Percent figures are the share of total factor decreased without hail suppression represented by the change.

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3. Borland, S.W., "Hail Suppression: Progress In Assessing Its Benefits and Costs," in <u>Preprint Volume 1</u>, NHRE Symposium on Hail, National Center for Atmospheric Research, Boulder, 1975.

Appendix table 1: SRG productivity subgroups within cost categories

LRA 64		LRA 65	
Cost category A	SRG (prod. index)	Cost category A	SRG (prod. index)
Subgroup 1:	710(60), 720(55)	Subgroup 1:	710(70), 720(60)
Subgroup 2:	726(35), 736(25)	Subgroup 2:	733(50), 726(45), 536(40), 731(40), 738(35)
Subgroup 3:	763(15), 733(10)	Subgroup 3:	763(15)
Cost category B		Cost category B	
Subgroup 1:	521(50), 522(50)	Subgroup 1:	510(75)
Subgroup 2:	722(40), 730(40), 791(40), 732(35)	Subgroup 2:	521(55), 522(55), 724(55), 722(50), 730(50)
Subgroup 3:	744(30), 550(25), 735(20)	Subgroup 3:	523(45), 531(45), 544(40), 550(40), 732(40), 744(40)
Subgroup 4:	741(15), 561(10), 562(10), 762(10)	Subgroup 4:	741(25), 541(20), 562(15), 762(15)
Cost category C		Cost category C	
Subgroup 1:	746(25), 740(20), 743(20)	Subgroup 1:	734(30), 740(30), 743(25), 761(25)
Subgroup 2:	734(10), 761(10), 773(10)		
Cost category D		Cost category D	
Subgroup 1:	760(10), 765(10), 771(5)	Subgroup 1:	745(25), 760(20), 765(10)

-Continued

Appendix table 1: SRG productivity subgroups within cost categories (Continued)

LRA 66

Cost category A	SRG (prod. index)
Subgroup 1:	710(75), 720(65)
Subgroup 2:	726(50)
Subgroup 3:	763(15)
Cost category B	
Subgroup 1:	510(80)
Subgroup 2:	522(55), 523(50), 722(50), 725(50), 730(50)
Subgroup 3:	732(45), 791(40)
Subgroup 4:	550(35), 741(25)
Cost category C	
Subgroup 1:	734(40), 739(40)
Subgroup 2:	743(30), 761(20), 740(30)
Cost category D	
Subgroup 1:	745(25), 760(20), 765(15)

LRA 67

Cost category A	SRG (prod. index)
Subgroup 1:	710(65), 720(60)
Subgroup 2:	733(45)
Subgroup 3:	763(15)
Cost category B	
Subgroup 1:	510(70)
Subgroup 2:	521(50), 522(50), 724(50), 722(45), 730(45), 523(40), 791(40)
Subgroup 3:	544(35), 732(35), 744(35), 750(35), 550(30), 534(25)
Subgroup 4:	735(20), 741(20), 561(15), 562(15)
Cost category C	
Subgroup 1:	734(25), 740(25)
Subgroup 2:	761(15)
Cost category D	
Subgroup 1:	745(20), 760(15)
Subgroup 2:	771(5)

-Continued

Appendix table 1: SRG productivity subgroups within cost categories (Continued)

LRA 71

Cost category A	SRG (prod. index)
Subgroup 1:	710(80), 721(75), 720(70)
Subgroup 2:	726(55), 536(50), 731(45), 738(45)
Subgroup 3:	763(20)
Cost category B	
Subgroup 1:	510(85)
Subgroup 2:	521(60), 522(60), 525(60), 535(60), 724(60), 523(55), 722(55), 730(55), 531(50), 732(50)
Subgroup 3:	735(45), 723(40), 791(40)
Subgroup 4:	741(30), 541(25), 561(25), 562(20), 742(20), 762(15)
Cost category C	
Subgroup 1:	734(40), 740(35)
Subgroup 2:	761(25)
Cost category D	
Subgroup 1:	760(25)

LRA 72

Cost category A	SRG (prod. index)
Subgroup 1:	710(65), 720(60)
Subgroup 2:	733(45), 736(30)
Subgroup 3:	726(20), 763(15)
Cost category B	
Subgroup 1:	510(70)
Subgroup 2:	521(50), 522(50), 525(45), 722(45), 730(45)
Subgroup 3:	523(40), 531(35), 535(35), 544(35), 732(35), 744(35), 791(35), 550(30), 723(30)
Subgroup 4:	534(25), 541(20), 735(20), 741(20), 561(15), 562(15)
Cost category C	
Subgroup 1:	740(25), 761(15)
Cost category D	
Subgroup 1:	760(15), 771(5)

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Appendix table 1: SRG productivity subgroups within cost categories (Continued)

LRA 73		LRA 75	
Cost category A	SRG (prod. index)	Cost category A	SRG (prod. index)
Subgroup 1:	710(80), 721(75), 720(70)	Subgroup 1:	710(85), 721(80), 720(75)
Subgroup 2:	763(20)	Subgroup 2:	731(55)
		Subgroup 3:	763(20)
Cost category B		Cost category B	
Subgroup 1:	510(85)	Subgroup 1:	510(90)
Subgroup 2:	521(60), 522(60), 724(60), 523(55), 722(55), 730(55)	Subgroup 2:	521(70), 522(70), 724(70), 523(65), 535(65), 722(65), 730(65), 737(60),
Subgroup 3:	531(50), 732(50), 534(45), 735(45), 791(45), 723(40)	Subgroup 3:	531(55), 534(55), 732(55), 723(50), 735(50), 791(50), 741(45)
Subgroup 4:	550(30), 741(30), 541(25), 562(20), 742(20), 561(25)	Subgroup 4:	541(35), 550(30), 742(30), 543(25), 562(25)
Cost category C		Cost category C	
Subgroup 1:	734(40), 740(35)	Subgroup 1:	740(50), 734(45)
Subgroup 2:	761(25), 770(10)	Subgroup 2:	761(25), 770(15)
Cost category D		Cost category D	
Subgroup 1:	760(25)	Subgroup 1:	760(30)
Subgroup 2:	771(5)		

-Continued

Appendix table 1: SRG productivity subgroups within cost categories (Continued)

LRA 102		LRA 106	
Cost category A	SRG (prod. index)	Cost category A	SRG (prod. index)
Subgroup 1:	710(90), 721(85), 720(80)	Subgroup 1:	710(95), 720(85)
Subgroup 2:	726(70), 536(60)	Subgroup 2:	731(65)
Subgroup 3:	738(55)	Subgroup 3:	763(30)
Subgroup 4:	763(25)		
Cost category B		Cost category B	
Subgroup 1:	510(95)	Subgroup 1:	510(100)
Subgroup 2:	522(80), 525(80), 724(80), 521(75), 523(75), 535(70), 722(70), 725(70), 730(70)	Subgroup 2:	522(85), 724(85), 521(80), 523(75), 525(75), 733(75), 730(75)
Subgroup 3:	732(65), 737(65), 531(60), 534(60), 723(60), 791(60), 735(55)	Subgroup 3:	535(70), 732(70), 791(70), 531(65), 534(65), 723(65)
Subgroup 4:	741(50), 541(45), 742(40)	Subgroup 4:	741(55), 541(50), 742(45)
Subgroup 5:	561(35), 550(30), 562(25), 580(5), 780(5)	Subgroup 5:	561(40), 550(35), 562(30)
Cost category C		Cost category C	
Subgroup 1:	739(60), 734(55), 740(55)	Subgroup 1:	734(60), 740(60)
Subgroup 2:	743(30), 761(30), 770(20)	Subgroup 2:	761(35), 770(25)
Cost category D		Cost category D	
Subgroup 1:	760(35), 765(35)	Subgroup 1:	760(40)

Appendix table 2: Cost per unit by LRA to produce the minimum cost crop pattern under four hail suppression assumptions, by crop, Nebraska

Crop	Suppression level *	Unit	64	65	66	67	71	72	73	75	102	106	State Ave.
	%						Dollars/units						
NI Wheat	0	bu.	.68	.65	.86	.75	.74	.65	.68	.70	.70	.68	.69
	10	"	.68	.65	.86	.74	.73	.65	.67	.70	.70	.68	.68
	25	"	.67	.65	.85	.73	.73	.64	.67	.69	.70	.68	.68
	50	"	.66	.64	.85	.72	.72	.63	.66	.69	.69	.67	.67
NI Other small grains	0	bu.	.56	.58	.58	.55	.69	.57	.67	.63	.68	.63	.65
	10	"	.56	.58	.58	.55	.69	.57	.67	.63	.68	.63	.64
	25	"	.55	.58	.58	.55	.68	.56	.63	.63	.68	.63	.64
	50	"	.54	.57	.57	.54	.68	.56	.62	.63	.68	.62	.64
NI Corn for grain	0	bu.	1.19	1.00	.81	1.44	.84	1.36	1.04	.74	.66	.62	.67
	10	"	1.19	1.00	.80	1.43	.83	1.35	1.03	.73	.66	.62	.67
	25	"	1.17	.99	.80	1.41	.83	1.33	1.02	.73	.66	.62	.67
	50	"	1.15	.98	.79	1.39	.82	1.30	1.01	.73	.65	.61	.66
NI Corn for silage	0	ton	7.49	7.17	7.27	6.56	6.33	7.90	6.22	5.95	6.00	5.71	6.03
	10	"	7.49	7.17	7.27	6.56	6.33	7.90	6.22	5.95	6.00	5.71	6.03
	25	"	7.49	7.17	7.27	6.56	6.33	7.90	6.18	5.95	6.00	5.71	6.03
	50	"	7.49	7.17	7.27	6.56	6.33	7.90	6.15	5.95	5.97	5.70	6.01
NI Sorghum for grain	0	bu.	1.00	.85	.72	1.26	.63	.90	.61	.50	.52	.49	.51
	10	"	1.00	.85	.72	1.26	.63	.89	.61	.50	.52	.49	.51
	25	"	1.00	.85	.72	1.26	.63	.88	.60	.49	.52	.49	.51
	50	"	1.00	.85	.72	1.26	.63	.87	.60	.49	.51	.48	.51
NI Sorghum for silage	0	ton	4.77	5.21	5.82	6.67	4.88	5.20	5.95	4.84	4.68	4.56	4.87
	10	"	4.77	5.19	5.82	6.67	4.88	5.20	5.95	4.84	4.68	4.56	4.87
	25	"	4.77	5.15	5.82	6.67	4.88	5.20	5.95	4.84	4.68	4.56	4.87
	50	"	4.77	5.11	5.82	6.67	4.88	5.20	5.95	4.82	4.68	4.55	4.86
NI Alfalfa	0	ton	20.00	17.99	19.14	21.30	15.99	18.21	14.73	14.88	14.83	14.96	15.32
	10	"	20.00	17.99	19.14	21.30	15.99	18.21	14.73	14.88	14.83	14.96	15.32
	25	"	20.00	17.99	19.14	21.30	15.99	18.62	14.73	14.88	14.83	14.96	15.31
	50	"	20.00	17.77	19.14	21.30	15.99	17.89	14.73	14.88	14.83	14.96	15.30
NI Other tame hay	0	ton	17.93	18.48	16.61	20.45	17.81	17.82	17.10	16.77	21.60	17.81	18.39
	10	"	17.91	18.48	16.61	20.45	17.81	17.82	17.10	16.77	21.60	17.81	18.39
	25	"	17.93	18.48	16.61	20.45	17.81	17.82	17.10	16.77	21.60	17.81	18.39
	50	"	17.93	18.48	16.44	20.45	17.81	17.82	17.10	16.77	21.60	17.81	18.37

Appendix table 2: Cost per unit by LRA to produce the minimum cost crop pattern under four hail suppression assumptions, by crop, Nebraska (Continued)

Crop	Suppression level *	Unit	64	65	66	67	71	72	73	75	102	106	State Ave.
	%						Dollars/unit						
NI Soybeans	0	bu.	--	--	--	--	1.37	--	1.46	1.04	1.23	1.06	1.15
	10	"	--	--	--	--	1.35	--	1.46	1.04	1.22	1.06	1.15
	25	"	--	--	--	--	1.33	--	1.45	1.03	1.22	1.06	1.14
	50	"	--	--	--	--	1.29	--	1.44	1.02	1.20	1.04	1.13
IR Wheat	0	bu.	.99	.97	--	1.09	.92	.98	.87	.93	1.07	--	.96
	10	"	.98	.97	--	1.08	.92	.97	.86	.93	1.07	--	.95
	25	"	.97	.96	--	1.07	.91	.96	.86	.93	1.06	--	.94
	50	"	.96	.94	--	1.04	.90	.94	.85	.92	1.05	--	.93
IR Corn for grain	0	bu.	.82	.78	.78	.82	.65	.70	.67	.62	.66	.69	.65
	10	"	.81	.78	.77	.82	.64	.69	.66	.62	.66	.69	.65
	25	"	.81	.77	.77	.81	.64	.68	.66	.62	.66	.69	.64
	50	"	.79	.77	.76	.80	.63	.67	.65	.61	.65	.68	.64
IR Corn for silage	0	ton	6.33	6.87	6.73	6.27	5.96	6.29	6.42	6.42	6.20	6.57	6.26
	10	"	6.33	6.87	6.73	6.27	5.96	6.29	6.40	6.42	6.20	6.57	6.26
	25	"	6.38	6.87	6.73	6.27	5.96	6.29	6.38	6.43	6.21	6.57	6.26
	50	"	6.40	6.87	6.73	6.27	5.96	6.29	6.34	6.39	6.18	6.56	6.25
IR Sorghum for grain	0	bu.	.61	.67	.59	.63	.51	.60	.50	.53	.49	.48	.52
	10	"	.61	.67	.59	.63	.51	.60	.50	.53	.49	.48	.52
	25	"	.61	.67	.59	.63	.51	.60	.50	.53	.49	.48	.52
	50	"	.61	.66	.58	.63	.51	.59	.50	.53	.49	.49	.51
IR Sorghum for silage	0	ton	5.23	5.30	--	4.76	5.21	5.10	5.24	5.26	5.08	--	5.16
	10	"	5.23	5.27	--	4.76	5.21	5.10	5.24	5.26	5.08	--	5.16
	25	"	5.23	5.22	--	4.76	5.21	5.10	5.24	5.26	5.08	--	5.16
	50	"	5.23	5.15	--	4.76	5.22	5.09	5.23	5.25	5.06	--	5.15
IR Alfalfa	0	ton	17.60	16.93	17.05	16.32	16.95	16.08	15.35	16.62	16.29	17.81	16.37
	10	"	17.60	16.93	17.05	16.32	16.95	16.08	15.35	16.62	16.29	17.81	16.37
	25	"	17.60	16.78	17.05	16.32	16.95	15.89	15.35	16.62	16.29	17.81	16.32
	50	"	17.60	16.66	17.05	16.32	16.95	15.87	15.35	16.62	16.29	17.81	16.30
IR Other tame hay	0	ton	18.14	20.81	--	--	--	--	--	17.23	--	--	17.58
	10	"	18.14	20.81	--	--	--	--	--	17.23	--	--	17.58
	25	"	18.14	20.81	--	--	--	--	--	17.23	--	--	17.58
	50	"	18.14	20.81	--	--	--	--	--	17.23	--	--	17.58

(2 of 3)

Appendix table 2: Cost per unit by LRA to produce the minimum cost crop pattern under four hail suppression assumptions, by crop, Nebraska (Continued)

Crop	Suppression level *	Unit	64	65	66	67	71	72	73	75	102	106	State Ave.
	%						Dollars/units						
IR Soybeans	0	bu.	--	--	--	--	1.11	--	1.25	1.21	1.21	1.10	1.17
	10	"	--	--	--	--	1.10	--	1.24	1.20	1.21	1.10	1.16
	25	"	--	--	--	--	1.08	--	1.24	1.19	1.21	1.10	1.15
	50	"	--	--	--	--	1.05	--	1.23	1.18	1.19	1.09	1.13
IR Sugar beets	0	Ton	12.26	12.69	--	10.37	12.44	12.27	12.18	11.87	12.35	--	10.99
	10	"	12.06	12.64	--	10.37	12.34	12.27	11.99	11.82	12.35	--	10.97
	25	"	11.77	12.53	--	10.37	12.20	12.27	11.72	11.74	12.35	--	10.94
	50	"	11.31	10.10	--	10.35	11.97	12.27	11.30	11.63	12.30	--	10.86

*0 = Without hail suppression

Appendix table 3: Percent of total State acreage located in each LRA, by crop, for four hail suppression assumptions, minimum cost crop patterns, Nebraska

Crop	Suppression level *	State Total Acres	64	65	66	67	71	72	73	75	102	106
			Percent									
NI Wheat (Production & fallow)	0	4,460,351	6.14	5.40	.01	10.35	5.19	28.46	14.92	21.15	2.21	6.15
	10	4,459,863	6.14	5.40	.01	10.36	5.18	28.46	14.92	21.16	2.21	6.15
	25	4,459,816	6.14	5.40	.01	10.36	5.19	28.46	14.92	21.16	2.21	6.15
	50	4,459,490	6.14	5.38	.01	10.36	5.19	28.46	14.93	21.16	2.21	6.15
NI Other small grains	0	549,039	4.52	8.50	4.84	5.29	3.64	6.84	1.75	3.67	57.57	3.37
	10	548,939	4.52	8.50	4.84	5.29	3.64	6.84	1.75	3.67	57.56	3.37
	25	550,085	4.51	8.49	4.83	5.28	3.64	6.83	4.26	3.67	55.14	3.37
	50	549,972	4.51	8.49	4.83	5.28	3.64	7.54	4.26	3.67	54.52	3.37
NI Corn for grain	0	2,434,046	.02	2.11	1.06	.01	5.04	1.41	1.10	4.46	62.05	22.73
	10	2,434,046	.02	2.11	1.06	.01	5.04	1.41	1.10	4.46	62.05	22.73
	25	2,434,046	.02	2.11	1.06	.01	5.04	1.41	1.10	4.46	62.05	22.73
	50	2,434,046	.02	2.11	1.06	.01	5.04	1.41	1.10	4.46	62.05	22.73
NI Corn for silage	0	274,333	.06	2.95	1.35	.45	8.20	1.06	4.46	6.07	63.57	11.82
	10	274,333	.06	2.95	1.35	.45	8.20	1.06	4.46	6.07	63.57	11.82
	25	274,333	.06	2.95	1.35	.45	8.20	1.06	4.46	6.07	63.57	11.82
	50	273,451	.06	2.96	1.36	.45	8.23	1.06	4.48	6.09	63.78	11.53
NI Sorghum for grain	0	1,582,559	.01	.17	1.23	.02	4.20	1.92	13.48	38.71	10.43	29.85
	10	1,582,672	.01	.17	1.23	.02	4.20	1.92	13.47	38.70	10.43	29.85
	25	1,582,872	.01	.17	1.23	.02	4.20	1.92	13.53	38.70	10.43	29.80
	50	1,579,609	.01	.17	1.23	.02	4.21	1.92	13.56	38.78	10.45	29.66
NI Sorghum for silage	0	107,054	.44	1.02	.86	.74	8.47	4.88	16.59	22.71	23.61	20.70
	10	107,054	.44	1.02	.86	.74	8.47	4.88	16.59	22.71	23.61	20.70
	25	107,054	.44	1.02	.86	.74	8.47	4.88	16.59	22.71	23.61	20.70
	50	107,510	.43	1.44	.85	.74	8.43	4.85	16.52	22.61	23.51	20.61
NI Alfalfa	0	1,286,167	1.36	8.73	2.36	.63	16.51	1.84	4.90	12.40	36.87	14.40
	10	1,286,167	1.36	8.73	2.36	.63	16.51	1.84	4.90	12.40	36.87	14.40
	25	1,283,635	1.36	8.74	2.37	.63	16.55	1.64	4.91	12.42	36.94	14.43
	50	1,286,167	1.36	8.73	2.36	.63	16.51	1.84	4.90	12.40	36.87	14.40

Appendix table 3: Percent of total State acreage located in each LRA, by crop, for four hail suppression assumptions, minimum cost crop pattersn, Nebraska (Continued)

Crop	Suppression level *	State Total Acres	64	65	66	67	71	72	73	75	102	106
			Percent									
NI Other tame hay	0	783,444	1.12	33.46	7.38	3.73	8.32	19.56	4.48	4.67	11.79	5.50
	10	783,439	1.12	33.45	7.38	3.73	8.32	19.56	4.48	4.67	11.79	5.50
	25	783,444	1.12	33.46	7.38	3.73	8.32	19.56	4.48	4.67	11.79	5.50
	50	783,206	1.12	33.57	7.38	3.73	8.32	19.56	4.48	4.67	11.79	5.50
NI Soybeans	0	733,678	--	.02	--	--	.03	--	.03	9.92	57.28	32.73
	10	733,661	--	.02	--	--	.03	--	.03	9.92	57.28	32.73
	25	733,671	--	.02	--	--	.03	--	.03	9.92	57.28	32.73
	50	733,617	--	.02	--	--	.03	--	.03	9.92	57.28	32.73
IR Wheat	0	2,107	14.05	20.60	--	6.79	11.44	27.62	14.52	3.56	1.42	--
	10	2,107	14.05	20.60	--	6.79	11.44	27.62	14.52	3.56	1.42	--
	25	2,107	14.05	20.60	--	6.79	11.44	27.62	14.52	3.56	1.42	--
	50	2,107	14.05	20.60	--	6.79	11.44	27.62	14.52	3.56	1.42	--
IR Corn for grain	0	2,169,809	.24	4.18	.01	2.42	22.32	5.22	8.67	42.65	12.84	1.46
	10	2,169,117	.24	4.18	.01	2.42	22.33	6.08	8.67	41.77	12.84	1.46
	25	2,169,509	.24	4.18	.01	2.42	22.32	6.08	8.67	41.78	12.84	1.46
	50	2,169,668	.24	4.18	.01	2.42	22.32	6.15	8.67	41.71	12.84	1.46
IR Corn for silage	0	136,930	5.89	6.69	.03	16.78	23.18	10.61	6.44	18.97	11.31	.09
	10	136,976	5.89	6.69	.03	16.78	23.17	10.61	6.44	18.99	11.30	.09
	25	136,302	2.74	6.72	.03	16.86	23.29	10.66	6.47	17.82	15.31	.09
	50	136,774	2.23	6.70	.03	16.73	23.21	10.63	6.45	22.62	11.32	.09
IR Sorghum for grain	0	166,108	.03	.23	.05	.06	10.19	1.20	19.88	54.86	5.57	7.93
	10	166,108	.03	.23	.05	.06	10.19	1.20	19.88	54.86	5.57	7.93
	25	166,108	.03	.23	.05	.06	10.19	1.20	19.88	54.86	5.57	7.93
	50	168,466	.03	.22	.05	.06	10.05	1.18	20.01	54.10	5.49	8.81
IR Sorghum for silage	0	10,410	1.83	2.85	--	1.87	19.39	12.49	5.44	26.20	29.24	--
	10	10,424	1.82	2.85	--	1.87	19.49	12.47	5.43	26.16	29.90	--
	25	10,434	1.82	3.61	--	1.87	18.80	12.45	5.42	26.14	29.87	--
	50	10,211	1.86	4.81	--	1.91	17.83	10.81	5.54	26.71	30.53	--
IR Alfalfa	0	244,966	2.02	11.62	.01	30.02	16.04	17.41	10.82	8.81	3.18	.06
	10	244,966	2.02	11.62	.01	30.02	16.04	17.41	10.82	8.81	3.18	.06
	25	246,360	2.01	11.56	.01	29.85	15.95	17.88	10.76	8.76	3.16	.06
	50	245,139	2.02	11.61	.01	30.00	16.03	17.47	10.82	8.81	3.18	.06

Appendix table 3: Percent of total State acreage located in each LRA, by crop, for four hail suppression assumptions, minimum cost crop patterns, Nebraska (Continued)

Cost	Suppression level	State Total Acres	64	65	66	67	71	72	73	75	102	106
						Percent						
IR Other tame hay	0	36,969	38.43	1.11	--	--	--	--	--	60.46	--	--
	10	36,969	38.43	1.11	--	--	--	--	--	60.46	--	--
	25	36,969	38.43	1.11	--	--	--	--	--	60.46	--	--
	50	36,969	38.43	1.11	--	--	--	--	--	60.46	--	--
IR Soybeans	0	49,943	--	--	--	--	39.50	--	.31	38.30	25.66	2.90
	10	49,943	--	--	--	--	39.50	--	.31	38.30	25.66	2.90
	25	49,943	--	--	--	--	39.50	--	.31	38.30	25.66	2.90
	50	49,943	--	--	--	--	39.50	--	.31	38.30	25.66	2.90
IR Sugarbeets	0	81,602	11.13	.31	--	64.16	1.44	21.47	.70	.12	.68	--
	10	81,628	11.12	.31	--	64.17	1.44	21.47	.70	.12	.68	--
	25	81,667	11.12	.31	--	64.19	1.44	21.46	.70	.12	.68	--
	50	81,716	11.11	.38	--	64.14	1.43	21.44	.70	.12	.68	--

* 0=Without Hail Suppression

Appendix table 4: Crop production by LRA with minimum cost crop patterns under four hail suppression assumptions, by crop, Nebraska

Crop	Suppression level *	Units	64	65	66	67	71	72	73	75	102	106
		Thou.										
NI Wheat	0	000 bu.	4,360	3,985	11	6,141	4,486	20,680	15,072	26,196	3,244	10,116
	10	"	4,404	4,024	11	6,220	4,515	20,897	15,195	26,319	3,254	10,139
	25	"	4,481	4,070	11	6,360	4,560	21,257	15,365	26,514	3,276	10,182
	50	"	4,601	4,161	11	6,577	4,625	21,798	15,628	26,826	3,305	10,245
NI Other small grains	0	000 bu.	1,020	1,716	969	1,163	786	1,686	355	869	13,045	860
	10	"	1,040	1,728	974	1,179	791	1,708	361	872	13,096	863
	25	"	1,070	1,747	981	1,202	799	1,744	944	877	12,577	863
	50	"	1,119	1,780	994	1,242	811	1,962	976	886	12,520	873
NI Corn for grain	0	000 bu.	12	1,549	1,004	6	5,474	916	872	5,844	90,406	38,310
	10	"	12	1,558	1,009	6	5,503	924	877	5,863	90,674	38,384
	25	"	12	1,569	1,017	6	5,547	937	886	5,900	91,126	38,384
	50	"	12	1,588	1,030	6	5,622	955	898	5,948	91,892	38,725
NI Corn for silage	0	000 tons	1	52	24	11	202	18	111	187	1,925	386
	10	"	1	52	24	11	202	18	111	187	1,925	386
	25	"	1	52	24	11	202	18	112	187	1,925	386
	50	"	1	52	24	11	202	18	113	187	1,940	378
NI Sorghum for grain	0	000 bu.	2	76	653	5	2,827	870	8,812	39,397	9,871	33,888
	10	"	2	76	655	5	2,834	876	8,847	39,457	9,888	33,941
	25	"	2	76	656	5	2,844	886	8,941	39,554	9,888	33,897
	50	"	2	76	660	5	2,865	901	9,015	39,684	9,972	33,823
NI Sorghum for silage	0	000 tons	4	9	6	4	99	48	123	290	302	314
	10	"	4	10	6	4	99	48	123	290	302	314
	25	"	4	10	6	4	99	48	123	290	302	314
	50	"	4	14	6	4	99	48	123	292	302	316
NI Alfalfa	0	000 tons	19	147	34	8	431	37	146	425	1,244	522
	10	"	19	147	34	8	431	37	146	425	1,244	522
	25	"	19	147	34	8	431	32	146	425	1,244	522
	50	"	19	150	34	8	431	39	146	425	1,244	522
NI Other tame hay	0	000 tons	11	311	81	31	97	219	51	60	135	69
	10	"	11	311	81	31	97	219	51	60	135	69
	25	"	11	311	81	31	97	219	51	60	135	69
	50	"	11	311	82	31	97	219	51	60	135	69

Appendix table 4: Crop production by LRA with minimum cost crop patterns under four hail suppression assumptions, by crop, Nebraska (Continued)

Crop	Suppression level *	Units	64	65	66	67	71	72	73	75	102	106
		Thou.										
NI Soybeans	0	000 bu.	--	4	--	--	4	--	4	1,995	10,611	6,769
	10	"	--	4	--	--	4	--	4	2,007	10,656	6,792
	25	"	--	4	--	--	4	--	4	2,021	10,656	6,793
	50	"	--	4	--	--	4	--	4	2,049	10,877	6,883
IR Wheat	0	000 bu.	9	16	--	4	10	21	13	3	1	--
	10	"	10	16	--	4	10	21	13	3	1	--
	25	"	10	16	--	5	10	21	13	3	1	--
	50	"	10	17	--	5	10	22	13	3	1	--
IR Corn for grain	0	000 bu.	400	8,770	14	4,344	53,304	11,257	19,701	102,963	30,650	3,333
	10	"	403	8,811	15	4,376	53,590	13,492	19,828	101,229	30,756	3,339
	25	"	408	8,882	15	4,422	54,009	13,667	19,997	101,805	30,904	3,339
	50	"	416	8,992	15	4,503	54,752	14,152	20,293	102,541	31,146	3,369
IR Corn for silage	0	000 tons	117	139	1	390	598	251	141	429	277	2
	10	"	117	139	1	390	598	251	142	430	277	2
	25	"	53	139	1	390	598	251	143	400	373	2
	50	"	43	139	1	388	598	251	145	517	279	2
IR Sorghum for grain	0	000 bu.	3	28	6	7	1,472	154	2,886	8,341	878	1,302
	10	"	3	28	6	7	1,475	155	2,896	8,350	880	1,304
	25	"	3	28	6	7	1,481	157	2,909	8,368	880	1,304
	50	"	3	28	6	7	1,491	160	2,998	8,403	887	1,463
IR Sorghum for silage	0	000 tons	3	5	--	4	35	25	10	51	60	--
	10	"	3	5	--	4	35	25	10	51	60	--
	25	"	3	7	--	4	34	25	10	51	60	--
	50	"	3	9	--	4	31	21	10	52	61	--
IR Alfalfa	0	000 tons	14	93	1/	238	144	163	109	83	30	1/
	10	"	14	93	1/	238	144	163	109	83	30	1/
	25	"	14	94	1/	238	144	173	109	83	30	1/
	50	"	14	96	1/	238	144	168	109	83	30	1/
IR Other tame hay	0	000 tons	34	1	--	--	--	--	--	64	--	--
	10	"	34	1	--	--	--	--	--	64	--	--
	25	"	34	1	--	--	--	--	--	64	--	--
	50	"	34	1	--	--	--	--	--	64	--	--

Appendix table 4: Crop production by LRA with minimum cost crop patterns under four hail suppression assumptions, by crop, Nebraska (Continued)

Cost	Suppression level *	Units	64	65	66	67	71	72	73	75	102	106
		Thou.										
IR Soybeans	0	000 bu.	--	--	--	--	730	--	5	656	336	56
	10	"	--	--	--	--	740	--	5	660	338	56
	25	"	--	--	--	--	753	--	5	665	338	56
	50	"	--	--	--	--	778	--	5	674	345	57
IR Sugarbeets	0	000 tons	136	4	--	950	19	276	9	2	9	--
	10	"	140	4	--	950	19	276	9	2	9	--
	25	"	145	4	--	951	19	276	10	2	9	--
	50	"	155	7	--	955	20	276	10	2	9	--

1/ Less than 500 units.

* 0 = Without Hail Suppression

Appendix table 5: Total factor demand (cost of production) by LRA in producing minimum cost crop patterns under four hail suppression assumptions, by crop, Nebraska

Crop	Suppression level *	64	65	66	67	71	72	73	75	102	106
		Thousand Dollars									
NI Wheat	0	2,970	2,609	10	4,605	3,305	13,455	10,190	18,332	2,269	6,860
	10	2,982	2,619	10	4,627	3,313	13,515	10,229	18,368	2,272	6,865
	25	3,004	2,629	10	4,664	3,326	13,617	10,278	18,422	2,278	6,878
	50	3,038	2,653	10	4,722	3,346	13,768	10,358	18,512	2,286	6,897
NI Other small grains	0	575	1,001	562	644	541	968	239	551	8,910	539
	10	581	1,005	564	649	543	975	240	552	8,923	539
	25	589	1,010	566	656	545	985	599	553	8,580	539
	50	604	1,020	569	669	549	1,101	609	556	8,502	542
NI Corn for grain	0	14	1,556	810	9	4,581	1,245	905	4,305	59,945	23,615
	10	14	1,556	810	9	4,583	1,245	905	4,306	59,975	23,624
	25	14	1,556	810	9	4,586	1,245	905	4,310	60,018	23,624
	50	14	1,556	810	9	4,591	1,245	905	4,315	60,096	23,666
NI Corn for silage	0	7	374	176	74	1,282	145	688	1,110	11,543	2,204
	10	7	374	176	74	1,282	145	689	1,110	11,543	2,204
	25	7	374	176	74	1,282	145	692	1,110	11,543	2,204
	50	7	374	176	74	1,282	145	695	1,110	11,585	2,152
NI Sorghum for grain	0	2	65	472	6	1,791	780	5,361	19,546	5,107	16,475
	10	2	65	472	6	1,792	781	5,365	19,557	5,109	16,485
	25	2	65	472	6	1,793	781	5,397	19,571	5,109	16,462
	50	2	65	472	6	1,796	782	5,406	19,950	5,122	16,379
NI Sorghum for silage	0	18	49	36	30	485	249	729	1,404	1,413	1,431
	10	18	50	36	30	485	249	729	1,404	1,413	1,431
	25	18	50	36	30	485	249	729	1,404	1,413	1,431
	50	18	72	36	30	485	249	729	1,409	1,413	1,437
NI Alfalfa	0	375	2,642	653	176	6,888	681	2,148	6,328	18,456	7,803
	10	375	2,642	653	176	6,888	681	2,148	6,328	18,456	7,803
	25	375	2,642	653	176	6,888	597	2,148	6,328	18,456	7,803
	50	375	2,668	653	176	6,888	691	2,148	6,328	18,456	7,803
NI Other tame hay	0	190	5,755	1,339	629	1,734	3,909	875	1,004	2,926	1,220
	10	192	5,753	1,339	629	1,734	3,909	875	1,004	2,926	1,220
	25	190	5,755	1,339	629	1,734	3,909	875	1,004	2,926	1,220
	50	190	5,749	1,352	629	1,734	3,909	875	1,004	2,926	1,220

Appendix table 5: Total factor demand (cost of production) by LRA in producing minimum cost crop patterns under four hail suppression assumptions, by crop, Nebraska (Continued)

Crop	Suppression level *	64	65	66	67	71	72	73	75	102	106
		Thousand Dollars									
NI Soybeans	0	--	--	--	--	6	--	6	2,077	13,037	7,174
	10	--	--	--	--	6	--	6	2,079	13,039	7,175
	25	--	--	--	--	6	--	6	2,080	13,039	7,175
	50	--	--	--	--	6	--	6	2,084	13,042	7,180
IR Wheat	0	9	16	--	5	9	20	11	3	1	--
	10	9	16	--	5	9	20	11	3	1	--
	25	9	16	--	5	9	20	11	3	1	--
	50	10	16	--	5	9	20	11	3	1	--
IR Corn for grain	0	328	6,858	11	3,564	34,454	7,887	13,136	63,968	20,287	2,291
	10	328	6,863	11	3,568	34,491	9,254	13,152	62,662	20,298	2,291
	25	329	6,871	11	3,572	34,538	9,270	13,173	62,735	20,317	2,291
	50	329	6,884	11	3,581	34,629	9,418	13,208	62,713	20,345	2,295
IR Corn for silage	0	744	953	4	2,443	3,565	1,579	909	2,755	1,719	13
	10	744	953	4	2,443	3,565	1,579	911	2,760	1,719	13
	25	340	953	4	2,443	3,565	1,579	914	2,572	2,318	13
	50	277	953	4	2,433	3,565	1,579	919	3,302	1,723	13
IR Sorghum for grain	0	2	19	3	4	757	93	1,456	4,435	430	631
	10	2	19	3	4	758	93	1,457	4,436	430	631
	25	2	19	3	4	758	93	1,458	4,437	430	631
	50	2	19	3	4	759	94	1,492	4,441	430	710
IRS Sorghum for silage	0	14	26	--	19	182	126	53	270	306	--
	10	14	26	--	19	184	126	53	270	306	--
	25	14	34	--	19	177	126	53	270	306	--
	50	14	45	--	19	164	106	53	271	307	--
IR Alfalfa	0	253	1,571	1	3,884	2,444	2,629	1,674	1,375	489	8
	10	253	1,571	1	3,884	2,444	2,629	1,674	1,375	489	8
	25	253	1,584	1	3,884	2,444	2,750	1,674	1,375	489	8
	50	253	1,594	1	3,884	2,444	2,764	1,674	1,375	489	8
IR Other tame hay	0	623	17	--	--	--	--	--	1,094	--	--
	10	623	17	--	--	--	--	--	1,094	--	--
	25	623	17	--	--	--	--	--	1,094	--	--
	50	623	17	--	--	--	--	--	1,094	--	--

Appendix table 5: Total factor demand (cost of production) by LRA in producing minimum cost crop patterns under four hail suppression assumptions, by crop, Nebraska (Continued)

Crop	Suppression level *	64	65	66	67	71	72	73	75	102	106
						Thousand Dollars					
IR Soybeans	0	--	--	--	--	811	--	6	792	408	61
	10	--	--	--	--	813	--	6	793	408	61
	25	--	--	--	--	815	--	6	794	408	61
	50	--	--	--	--	820	--	6	795	409	62
IR Sugarbeets	0	1,668	49	--	9,853	231	3,385	109	19	106	--
	10	1,685	49	--	9,858	232	3,385	110	19	106	--
	25	1,709	49	--	9,866	234	3,385	112	19	106	--
	50	1,754	70	--	9,885	236	3,385	115	20	107	--

* 0 = Without Hail Suppression